

**U.S. FISH AND WILDLIFE SERVICE  
SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM**

SCIENTIFIC NAME: *Consolea corallicola* (Small)

COMMON NAME: Florida semaphore cactus

LEAD REGION: 4

INFORMATION CURRENT AS OF: May 2010

**STATUS/ACTION:**

☐ Species assessment - determined species did not meet the definition of endangered or threatened under the Act and, therefore, was not elevated to Candidate status

☐ New candidate

☒ Continuing candidate

☐ Non-petitioned

☒ Petitioned - Date petition received: May 11, 2004

☐ 90-day positive - FR date:

☐ 12-month warranted but precluded - FR date:

☐ Did the petition request a reclassification of a listed species?

**FOR PETITIONED CANDIDATE SPECIES:**

a. Is listing warranted (if yes, see summary of threats below)? yes

b. To date, has publication of a proposal to list been precluded by other higher priority listing actions? yes

c. If the answer to a. and b. is "yes", provide an explanation of why the action is precluded. Higher priority listing actions, including court-approved settlements, court-ordered and statutory deadlines for petition findings and listing determinations, emergency listing determinations, and responses to litigation, continue to preclude the proposed and final listing rules for the species. We continue to monitor populations and will change its status or implement an emergency listing if necessary. The "Progress on Revising the Lists" section of the current CNOR (<http://endangered.fws.gov/>) provides information on listing actions taken during the last 12 months.

☐ Listing priority change

Former LP: ☐

New LP: ☐

Date when the species first became a Candidate (as currently defined): October 25, 1999

☐ Candidate removal: Former LP: ☐

☐ A - Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status.

☐ U - Taxon not subject to the degree of threats sufficient to warrant issuance of a

proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species.

- ☐ F - Range is no longer a U.S. territory.
- ☐ I - Insufficient information exists on biological vulnerability and threats to support listing.
- ☐ M - Taxon mistakenly included in past notice of review.
- ☐ N - Taxon may not meet the Act's definition of "species."
- ☐ X - Taxon believed to be extinct.

ANIMAL/PLANT GROUP AND FAMILY: Flowering plants, Cactaceae, Cactus Family

HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE: Florida, U.S.A.

CURRENT STATES/ COUNTIES/TERRITORIES/COUNTRIES OF OCCURRENCE:  
Florida, Monroe and Miami-Dade Counties, U.S.A.

LAND OWNERSHIP: There are two naturally occurring populations and a few outplanted populations. The Nature Conservancy (TNC) owns and maintains the Torchwood Hammock Preserve on Little Torch Key in Monroe County where one population occurs in an area approximately 0.4 hectares (ha) (1.0 acre (ac)) in size (Florida Natural Areas Inventory [FNAI] 2007, p. 288-289). The second population occurs in Miami-Dade County on Swan Key in Biscayne National Park (BNP), which is managed by the National Park Service (NPS). Swan Key is 48 ha (119 ac) in size, but plants are only found at the edge of a hammock. Outplantings have occurred in Monroe County, including: (1) an outplanting of 96 cacti on an undisclosed island in the lower Keys; (2) a total of 4 outplantings (170 plants) at 5 different locations at Dagny Johnson Key Largo Hammock Botanical State Park on North Key Largo, which is managed by the Florida Department of Environmental Protection (FDEP); (3) outplantings (40 plants/key) were attempted on 6 separate lower Keys on Federal and State lands, and (4) an outplanting of 180 cacti at Saddlebunch Key (Federal land).

LEAD REGION CONTACT: Erin Rivenbark, Atlanta Regional Office, 404-679-7379,  
erin\_rivenbark@fws.gov

LEAD FIELD OFFICE CONTACT: Paula Halupa, South Florida Ecological Services Office,  
772-562-3909 ext 257, paula\_halupa@fws.gov

#### BIOLOGICAL INFORMATION:

Species Description: The Florida semaphore cactus is an erect, trunk-forming cactus endemic to the Florida Keys. It generally grows 1 - 3 meters (m) (3 – 10 feet [ft]) in height with a trunk 0.5 - 2.5 m (2 – 8 ft) in length and 7.5 centimeters (3 inches) in diameter (Bradley and Gann 1999, p. 76-77). The branches usually grow in one or multiple planes from the trunk. They are copiously spiny and the spines are not barbed. Flowers are orange turning red with age (Bradley and Gann 1999, p. 76), and fruits are yellow (Wright and Maschinski 2004, p. 1). Unfertilized flowers revert to a vegetative branch or drop as a dispersal unit (Wright and Maschinski 2004, p. 1).

Two distinct flower morphs have been identified from plants in the *ex situ* collection maintained

at Fairchild Tropical Botanic Garden (FTBG) and on Little Torch Key. The primary flowers, produced along the margin of the cladodes, are morphologically and superficially hermaphroditic (i.e., the primary sex characters, stamens and carpels are expressed). Numerous secondary flowers, the majority of which lack a gynoecium (primary female parts of the flower), originate from aborted pericarpels that remain attached to the plant. These morphs bear viable pollen grains, but the majority lack a gynoecium. In both morphs the anthers develop normally and produce viable pollen grains. The ovules of the primary flowers complete development but the majority exhibit abortion prior to anthesis. Most pericarpels abscise without initiation of fruits (Negrón-Ortiz and Strittmatter 2004, p. 16, 18). Very few seeds have ever been observed to form and they are thought to be the product of asexual seed reproduction (agamospermy). These seeds sometimes germinate within the fallen fruit. While viviparity (seeds germinating while still attached to parent plant) is known from the Cactaceae, germination of seed within fallen fruits has apparently not been reported from this family (Negrón-Ortiz 1998, p. 4).

Floral morphology indicates that this species is hermaphroditic with perfect flowers (i.e., each flower produces pollen and ovules). The population on Little Torch Key is thought to be cryptically dioecious (i.e., the functional unisexual morphs appear to have perfect flowers making the dioecious condition difficult to detect). Individuals that produced viable pollen grains but never set fruit or bear a few fruits were designated as males. The extant population on Little Torch Key is therefore believed to be comprised of two sexual morphs: males and weak hermaphrodites. The female sexual morph is absent from the population on Little Torch Key (Negrón-Ortiz and Strittmatter 2004, p. 22). Cariaga *et al.* (2005, p. 225) found no genetic diversity within two wild populations (i.e., Little Torch Key and Swan Key populations). These results are consistent with previous reproductive studies suggesting that this species does not propagate sexually and that asexual reproduction is the primary reproductive strategy for this species (Cariaga *et al.* 2005, p. 225, 230). Sexual reproduction is the basis for species adaptation through natural selection. More research is required to determine whether or not the species is capable of sexual reproduction. If it is, then populations consisting of only males will lack the capacity for adaptation and will be more prone to extinction (see Factor E). Negrón-Ortiz (2007a, p. 5; 2007b, p. 1364) found that this species is a hexaploid; chromosome number determined with meiotic and somatic counts for the population at Swan Key was equal to the somatic counts for the Little Torch Key population.

During their monitoring work at Swan Key, Grahl and Bradley (2005, p. 2, 5) found growth and pad production was greatest between April and July. The number of vegetative pads decreased during the late summer months (July – October), which coincided with hurricane season. Grahl and Bradley (2005, p. 5) did not find differences between growth periods for adults and juveniles; however, growth for propagules was highest during the rainy season (April to October), suggesting a longer growth period than adults. Flower production occurred throughout the year with a noticeable peak from January through April and was at its lowest during the rainy season (April to October) (Grahl and Bradley 2005, p. 5-6). FTBG identified micorrhizal associates of *C. corallicola* as an *Acorus* type characterized by intercellular non-septate hyphae with vesicles. FTBG also investigated the effects of inoculating *ex situ* plants with micorrhizal fungi and found that the inoculated plants actually grew somewhat slower over a 72-month period than those not inoculated (Maschinski *et al.* 2002, p. 101).

**Taxonomy:** Lemaire segregated the genus *Consolea* from *Opuntia* in 1862 (Areces-Mallea 1996, p. 224-226) based on its distinctive cylindrical (unsegmented) trunk, asymmetric distal branches, and small flowers. However, the genus *Consolea* was not recognized by Britton and Rose (1919, p. 24) in their seminal treatment of the Cactaceae. Advances in molecular genetics have supported a more recent revision of the genus *Opuntia*. Several authors clearly support the distinctness of this genus based on the characters used by Lemaire, the nectar chamber covered by the thickening of the style, and embryological, palynological, and molecular data (Areces-Mallea 1996, p. 224-226; Parfitt and Gibson 2004, p. 92-94; V. Negrón-Ortiz, pers. comm. 2006a). The current classification of opuntoid species for the U.S. distinguishes five genera (*Consolea*, *Cylindropuntia*, *Grusonia*, *Nopalea*, and *Opuntia*) that were previously classified as *Opuntia* (Parfitt and Gibson 2004, p. 92-94). Although most researchers recognize the genus *Consolea*, many have been slow to incorporate the new name into documents and websites and still refer to it as *Opuntia corallicola* instead of *Consolea corallicola*. For example, the Integrated Taxonomic Information System (ITIS) (2010, p. 1) indicates that the taxonomic standing for *Consolea corallicola* Small is not accepted. The online Atlas of Florida Vascular Plants (Wunderlin and Hansen 2008, p. 1) uses the name *Opuntia corallicola* (Small) Werderm. NatureServe (2009, p. 1) uses the name *Opuntia corallicola*.

John Kunkel Small discovered the Florida semaphore cactus and named it *Consolea corallicola* (Small 1930, p. 25-26). In 1971, Long and Lakela (1971, p. 626) reassigned the Florida Keys plants to *Opuntia spinosissima* Miller, a species restricted to the Blue Hills of south coastal Jamaica. Austin *et al.* (1998, p. 151-158) determined that the Florida semaphore cactus is not *O. spinosissima* and should be named *O. corallicola*. It has since been determined that the Florida semaphore cactus is both morphologically and genetically unique and should be recognized as a distinct species and separated from the genus *Opuntia* into the genus, *Consolea* (Austin *et al.* 1998, p. 151-158; Gordon and Kubisiak 1998, p. 203-210).

The genus *Opuntia* (Cactaceae), which has historically included all of the prickly-pears, chollas, and club-chollas, is being taxonomically split up. However, due to a new consensus among modern cactus taxonomists (e.g., Anderson 2001), especially with the aid of molecular studies, the genus has been divided and many of the subgenera are now recognized at the generic level. The current classification of opuntoid species recognizes fifteen genera worldwide, including *Consolea*.

The Service has carefully reviewed the available taxonomic information to reach the conclusion that *Consolea corallicola* (Small) is a valid taxon.

**Habitat:** This cactus grows close to salt water on bare rock with a minimum of humus-soil cover in hammocks near sea level (Small 1930, p. 25-26; Benson 1982, p. 531). Gann *et al.* (2002, p. 480) characterized habitats as including low buttonwood transition areas between rockland hammocks and mangrove swamps and possibly other habitat such as openings in rockland hammocks. On Swan Key this species only occurs near the center of the island where it grows approximately 0 to 10 meters (32.8 feet) from the edge of the hammock, which is embedded in tidal swamp dominated by red mangrove (*Rhizophora mangle*) (Grahl and Bradley 2005, p. 4). Grahl and Bradley (2005, p. 4) suggested that conditions are probably too shady beyond the hammock edge to support optimal plant growth. At this site, plants most likely do not grow in

the sunny edge outside of the hammock because of periodic tidal flooding (Grahl and Bradley 2005, p. 4). Grahl and Bradley (2005, p. 4) defined two subpopulations on the island, one along the north edge and one along the south. Although no quantitative measurements were made of habitat differences between both sites, there appeared to be more sunlight in the south (especially during the winter) and less litter and soil (Grahl and Bradley 2005, p. 4).

The plants on Little Torch Key grow in a low buttonwood forest habitat (K. Bradley, The Institute for Regional Conservation [IRC], pers. comm. 2007). Most plants are on the edge of the hammock / buttonwood transition zone or directly in the transition zone (A. Higgins, TNC, pers. comm. 2007). Plants occur in a mixture of sun to shade, although the adult plants in the shade appear healthier than adults in the sun. An experimental outplanting was conducted to determine optimal growth conditions. Plants in the shade were taller and produced fewer pads, whereas plants in the sun were shorter, but developed more pads. It is believed that plants in sunny conditions experience higher salt levels than those in shady locations and this may contribute to their stunted growth (Stiling *et al.* 2000, p. 4).

Historical Range/Distribution: The species was discovered on Big Pine Key in 1919 (Small 1930, p. 25-26). By the 1960s, it was extirpated from Big Pine Key by road building and poaching (Bradley and Gann 1999, p. 77; Bradley and Koop 2003, p. 3). In the 1960s, a second population was discovered on Little Torch Key, an island immediately west of Big Pine Key (Bradley and Gann 1999, p. 77; Gann *et al.* 2002, p. 480; Bradley and Koop 2003, p. 3). Small (1930, p. 25-26) reported the species occurred in Key Largo in the upper Keys; however no reference was given as to the size or number of individuals. Data from IRC indicate that the occurrences on Key Largo are extirpated; however, no date or causes of the extirpation at this site are given (K. Bradley, pers. comm. 2007).

Current Range/Distribution: Until 2001, the only known extant Florida semaphore cactus occurrence was a single wild population on Little Torch Key, comprised of a few, declining mature plants at the Torchwood Hammock Preserve. In November 2001, a new colony was found at Swan Key in BNP (Bradley and Woodmansee 2002, p. 810; Gann *et al.* 2002, p. 480; Bradley and Koop 2003, p. 3). This population is approximately 140 kilometers (km) (87 miles (mi)) from Big Pine Key (Bradley and Woodmansee 2002, p. 810), the closest historically documented occurrence, and 145 km (90 mi) from Little Torch Key (Bradley and Koop 2003, p. 2). A survey of all other areas containing suitable habitat in BNP and Palo Alto Key in the adjacent John Pennekamp Coral Reef State Park was undertaken in 2002 and 2003 to locate additional colonies, but none were found (Bradley and Koop 2003, p. 2).

Experimental outplantings were conducted in 1996, 1998, 2000, 2003, and 2004 due to the species' rarity and threat of infestations of the cactus moth (*Cactoblastis cactorum*) (Stiling 2007, p. 2; J. Duquesnel, FDEP, pers. comm. 2008, 2009). Gann *et al.* (2002, p. 481) indicated that attempts to translocate this species occurred at several sites: National Key Deer Refuge on Big Pine Key; Spoonbill Sound Hammocks, Florida Keys Wildlife and Environmental Area on Cudjoe Key; Dagny Johnson Key Largo Hammock Botanical State Park on North Key Largo; Little Torch Key; and Ramrod Hammocks, Florida Keys Wildlife and Environmental Area on Ramrod Key. Another reintroduction project was reported for No Name Key and Upper Sugarloaf Key. Some plants were reintroduced to a small plot within Cactus Hammock at

National Key Deer Refuge (P. Hughes, Service, pers. comm. 2007). An outplanting also occurred on Saddlebunch key in 1998 (P. Stiling, pers. comm. 2009).

The species was not found during a two-year project intended to survey and map exotic and rare plants along Florida Department of Transportation (FDOT) right-of-ways within Miami-Dade and Monroe counties (Gordon *et al.* 2007, p. 1, 40).

Population Estimates/Status: The population on Little Torch Key is small. Data from IRC indicate that there are 13 plants remaining at this site (K. Bradley, pers. comm. 2007). TNC indicates that they monitor nine different surviving plants which consist of six adults (generally taller than 3 feet) and a wide ranging number of vegetative recruits (from none to hundreds) surrounding each (A. Higgins, pers. comm. 2007). Overall, the population on Little Torch Key has been in decline for over four years (A. Higgins, pers. comm. 2007). There is thought that this decline may be from sea level rise since most of the plants are in the hammock / buttonwood transition zone or directly in the buttonwood transition zone (A. Higgins, pers. comm. 2007). The regeneration in this population is restricted to clonal propagation because it was believed that all remaining individuals in this population were functionally male (Negrón-Ortiz 1998, p. 208-212). Work regarding fruit and pollen production in some males suggested that this population consists of males and weak hermaphrodites (Negrón-Ortiz and Strittmatter 2004, p. 22).

The population size at Swan Key (BNP) was estimated on a log<sub>10</sub> scale as 100-1,000 (K. Bradley, pers. comm. 2007). A 2002 survey tagged or mapped 586 plants, 44 percent of which were adults (plants with vegetative pads) and 56 percent were juveniles (Bradley and Koop 2003, p. 4). Cariaga *et al.* (2005, p. 225) estimated the population size at 570 plants. During monitoring work conducted in 2005, IRC tagged a total of 655 plants at two sites on Swan Key of which 490 (67.7 percent) were adults and 234 (32.3 percent) were juveniles (Grahl and Bradley 2005, p. 2, 4). Objectives of this study were to determine the demographic trends of Florida semaphore cactus on Swan Key, detect infestations of the cactus moth if they occur, and facilitate response and management by appropriate agencies. No evidence of the cactus moth or poaching was found (Grahl and Bradley 2005, p. 2, 4). Overall, the cactus population on Swan Key appeared relatively stable; mortality was low (9 percent), but higher than the previous year (2 percent), possibly due to hurricane activity (Grahl and Bradley 2005, p. 2, 6). High winds associated with hurricanes caused a high number of vegetative pads to fall off (Grahl and Bradley 2005, p. 2, 6). In 2008, the population was estimated by BNP staff to consist of at least 600 plants, and there was no sign of damage from the cactus moth or evidence of poaching (V. McDonough, BNP, pers. comm. 2008). In 2009, the population was estimated by BNP staff to be approximately 600 individuals (V. McDonough, pers. comm. 2010a). Mortality is mostly due to the loss of small recruits (<10 centimeters [cm] [<3.9 inches]); no evidence of the cactoblastis moth was found (V. McDonough, pers. comm. 2010a). Overall, the population at Swan Key appears to be stable (V. McDonough, pers. comm. 2010a).

Table 1: Summary of known, extant occurrences of Florida semaphore cactus (natural occurrences remaining). Data are from Slapcinsky *et al.* (2006, p. 1-12), Higgins (pers. comm. 2007), Bradley (pers. comm. 2007), and V. McDonough (pers. comm. 2010a, 2010b).

Location	Numbers (year recorded)	Functional	Threats
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		<i>Status</i>	
Little Torch Key	13 (2007); 6 adults and 0-100s vegetative recruits (2007)	declining, all male	cactoblastis moth, collection, vandalism, root rot, hurricanes and storm surge, sea-level rise
Swan Key in Biscayne National Park	100-1,000 (log <sub>10</sub> scale; 2007); 600 individuals (2008,2009)	stable, all male	cactoblastis moth, collection, invasive exotic species, hurricanes and storm surge, sea-level rise

Experimental outplantings were conducted in 1996, 1998, 2000, 2003, and 2004. Ninety-six cacti were outplanted in the lower Keys in 1996; some plants were caged and some were not (Stiling 2007, p. 2). Cages protected cacti from *Cactoblastis*, but attracted large mammals (probably Key deer [*Odocoileus virginianus clavium*]), reason not specified), which destroyed the cages and trampled the cacti inside, resulting in death (Stiling 2007, p. 2). By the end of the study in November 1998 there were few signs of growth and a 34.4 percent decline (Stiling *et al.* 2000, p. 5). Most of the cacti died from root rot; none survived (Stiling 2007, p. 2). The second outplanting, in 1998, involved 180 cacti planted (without cages) (Stiling 2007, p. 2). Over 50 percent of the cacti were killed by *Cactoblastis* within 3 years and over 40 percent died from root rot from 1998 – 2006; nine of these cacti are alive (Stiling 2007, p. 2). The third outplanting in 2000, involving 40 plants at each of six islands, was conducted in shady hammocks in rich soil with added fertilizer (Stiling 2007, p. 2). *Cactoblastis* attack was zero, but over 75 percent of cacti were killed by root rot within 6 years. Outplantings showed that cacti can be fairly easily propagated in a greenhouse and then outplanted in the field. However, survival rate of outplanted cacti has been poor because of root rot (Stiling 2007, p. 2). Recent analyses have shown that vegetative recruit survival and growth is not linked to physical parameters (i.e., light levels, soil moisture levels, soil pH, soil salinity and soil nutrient levels) (Stiling 2007, p. 2).

Although considerable efforts have been made to reintroduce this species to suitable sites, outplanting success has been poor. Plants at Big Pine Key, Cudjoe Key, Ramrod Key, and No Name Key have all died (P. Stiling, pers. comm. 2009). Only seven plants from 180 individuals remain at Saddlebunch Key from the 1998 outplanting (P. Stiling, pers. comm. 2009). Only eight of 142 outplanted individuals remained alive at Dagny Johnson Key Largo Hammock State Botanical Park in November 2008 from efforts in 1996, 2003, and 2004 (J. Duequesnel, pers. comm. 2009).

Table 2: Summary of remaining plants from numerous outplanting efforts (1996, 1998, 2000, and 2004). Data are from P. Stiling (pers. comm. 2009) and J. Duequesnel (pers. comm. 2009).

<i>Location</i>	<i>Numbers remaining</i>	<i>Functional status</i>	<i>Threats , potential causes of decline</i>
NKDR, Big Pine Key	0	outplanted; plants died	root rot, cactoblastis moth, trampling, stem browning (pathogen), unknown

			factors
Spoonbill Sound Hammocks, Cudjoe Key	0	outplanted; plants died	root rot, unknown factors
North Key Largo, Dagny Johnson	142 outplanted (1996, 2003, 2004); 8 remained in 2008	declining, unknown	root rot, unknown factors
Little Torch Key	unknown	unknown	root rot, unknown factors
Ramrod Hammock, Ramrod Key	0	outplanted; plants died	root rot, unknown factors
No Name Key	0	outplanted; plants died	root rot, unknown factors
Upper Sugarloaf Key	unknown	unknown	root rot, unknown factors
Saddlebunch Key	180 outplanted in 1998; 7 remained in 2009	declining, unknown	root rot, unknown factors

Inspection of flowers during 2005-2006 indicated that the population on Swan Key consists of only functional male individuals, similar to the Little Torch Key population (Negrón-Ortiz 2007a, p. 3; 2007b, p. 1362). Pollination studies were not initiated because only one sexual morph was present or observed. Developing fruits were not observed in the population; developing fruits would have indicated the presence of females and hermaphrodites (Negrón-Ortiz 2007a, p. 3). Although the flowers have ovules, at anthesis (flower opening) these ovules are aborted; therefore they do not set seeds (Negrón-Ortiz 2007a, p. 4; 2007b, p. 1316). The development of the anthers and pollen grains progress normally, resulting in numerous, viable pollen grains (Negrón-Ortiz 2007a, p. 4; 2007, p. 1367). Research by Francisco-Ortega *et al.* (2004, p. 3, 8-9) using molecular markers indicated that all plants from the Swan Key population were genetically identical and the same is true for plants from Little Torch Key.

FTBG has worked on new DNA fingerprinting techniques for managing wild populations (Lewis 2007, p. 1-5). FTBG has examined levels of genetic diversity within and between populations as well as diversity among plants of known origin. Researchers found no evidence of genetic variation within two populations (C. Lewis, FTBG, pers. comm. 2006). These findings support the conclusion that the Swan Key (upper Keys) and Little Torch Key populations and the Big Pine Key (lower Keys) individual (single plant in *ex situ* collection) are clonally derived and genetically distinct from each other (Cariaga *et al.* 2005, p. 229-231; Lewis 2007, p. 6). These findings are also consistent with emerging data on the reproductive biology of the species, which indicates that all known wild and cultivated plants are male (Negrón-Ortiz 1998, p. 208-212; Negrón-Ortiz and Strittmatter 2004, p. 22; Lewis 2007, p. 6). Results from microsatellite fragment patterns suggest that the Big Pine Key plant is genetically identical to the Little Torch Key plants (Lewis 2007, p. 6-7). According to Lewis (2007, p. 6-7), this is in conflict with the results of Cariaga *et al.* (2005, p. 229-231), who found several loci that distinguished the Big Pine Key and Little Torch Key plants. Lewis (pers. comm. 2006) suggested that the genetic diversity of the species can be maintained in a small *ex situ* collection.

FNAI (2010a, p. 14; 2010b, p. 7) considers the global status of the Florida semaphore cactus to be G1, critically imperiled. NatureServe (2009, p. 1) considers its global status G1, critically imperiled. It is listed as endangered by the State.

#### THREATS:

- A. The present or threatened destruction, modification, or curtailment of its habitat or range.  
Destruction or modification of habitat as a result of development is a threat throughout the range of the Florida semaphore cactus, but this threat is not imminent. The only known wild (i.e., Swan Key, Little Torch Key) and reintroduced populations and all outplanting attempts (Dagny Johnson Key Largo Hammock Botanical State Park and National Key Deer Refuge) are secure; however, habitat throughout the former range is under intense development pressure. Data from IRC indicate that development and road-building were the causes of this species' original extirpation on Big Pine Key (K. Bradley, pers. comm. 2007). Residential and commercial development and roadway construction continue to occur throughout Miami-Dade and Monroe Counties, and specifically in the Keys. All available vacant land in the Keys is projected to be consumed by development by 2060, including lands not necessarily accessible by automobile (Zwick and Carr 2006, p. 14).

Climatic changes and sea level rise are considered major threats (Gann *et al.* 2002, p. 481; A. Higgins, pers. comm. 2007; J. Duquesnel, pers. comm. 2008) to the species and its habitat. The extant populations occur near sea level in a transitional zone between mangrove and hardwood hammock habitats (NatureServe 2009, p. 1). The population on Little Torch Key has been in decline for more than four years, and this may be partially attributed to sea level rise, as most of the cacti are on the edge of the hammock / buttonwood transition zone or directly in the transition zone (A. Higgins, pers. comm. 2007). Sea level rise could cause increases in flooding frequency or duration, prolonged or complete inundation of plants, and loss of suitable habitat.

The Intergovernmental Panel on Climate Change (IPCC) reported that the warming of the world's climate system is unequivocal based on documented increases in global average air and ocean temperatures, unprecedented melting of snow and ice, and rising average sea level (IPCC 2007, p. 2; 2008, p. 15). Sea-level rise is the largest climate-driven challenge to low-lying coastal areas and refuges in the sub-tropical ecoregion of southern Florida (U.S. Climate Change Science Program [CCSP] 2008, p. 5-31, 5-32). The long-term record at Key West shows that sea level rose on average 0.088 inches (0.224 cm) annually between 1913 and 2006 (National Oceanographic and Atmospheric Administration [NOAA] 2008, p. 1). This equates to approximately 8.76 inches (22.3 cm) over the last 100 years (NOAA 2008, p. 1).

IPCC (2008, p. 28) emphasized it is very likely that the average rate of sea-level rise during the 21<sup>st</sup> century will exceed that from 1961 to 2003 (i.e., 0.071 inches [0.18 cm] per year), although it was projected to have substantial geographical variability. Partial loss of the Greenland and, or Antarctic ice sheets could result in many feet (several meters) of sea-level rise, major changes in coastlines, and inundation of low-lying areas (IPCC 2008, p. 28-29).

Low lying islands and river deltas will incur the largest impacts (IPCC 2008, p. 28-29). Because dynamic ice flow processes in ice sheets are poorly understood, timeframes are not known; however, modeling indicates that “more rapid sea-level rise on century timescales cannot be excluded” (IPCC 2008, p. 29). According to CCSP (2008, p. 5-31), much of low-lying, coastal south Florida “will be underwater or inundated with salt water in the coming century.”

IPCC (2008, p. 3, 103) concluded that “climate change is likely to increase the occurrence of saltwater intrusion into coastal aquifers as sea level rises” and that “sea-level rise is projected to extend areas of salinisation of groundwater and estuaries, resulting in a decrease of freshwater availability for humans and ecosystems in coastal areas”. From the 1930s to 1950s, increased salinity of coastal waters contributed to the decline of cabbage palm forests in southwest Florida (Williams *et al.* 1999, p. 2056-2059), expansion of mangroves into adjacent marshes in the Everglades (Ross *et al.* 2000, p. 9, 12-13), and loss of pine rockland in the Keys (Ross *et al.* 1994, p. 144, 151-155). Hydrology has a strong influence on plant distribution in these and other coastal areas (IPCC 2008, p. 57). Such communities typically grade from salt to brackish to freshwater species. In the Keys, not only are elevation differences between such communities very slight (Ross *et al.* 1994, p. 146), but the horizontal distances are small as well. Human developments will also likely be significant factors influencing whether natural communities can move and persist (IPCC 2008, p. 57; CCSP 2008, p. 7-6).

TNC (2010, p. 1) used high-resolution digital elevation models derived from highly accurate Light Detection and Ranging (LIDAR) remote sensing technology to predict future shorelines and distribution of habitat types for Big Pine Key based on sea level rise predictions ranging from the best-case to worst-case scenarios described in current scientific literature. In the Florida Keys, TNC models predicted that sea level rise will first result in the conversion of habitat, and eventually the complete inundation of habitat. In the best-case scenario, a rise of 7 inches (18 cm) would result in the inundation of 1,840 acres (745 ha) (34 percent) of Big Pine Key and the loss of 11 percent of the island’s upland habitat (TNC 2010, p. 1). In the worst-case scenario, a rise of 4.6 feet (140 cm) would result in the inundation of about 5,950 acres (2,409 ha) (96 percent) and the loss of all upland habitat (TNC 2010, p. 1).

Similarly, using a spatially explicit model for the Keys, Ross *et al.* (2009, p. 473) found that mangrove habitats will expand steadily at the expense of upland and traditional habitats as sea level rises. Most of the upland and transitional habitat in the central portion of Sugarloaf Key is projected to be lost with a 0.7-foot (0.2 m-) rise in sea level; a 1.6-foot (0.5-m) rise in sea level can result in a 95 percent loss of upland habitat by 2100 (Ross *et al.* 2009, 473). Furthermore, Ross *et al.* (2009, p. 471-478) suggest that interactions between sea-level rise and pulse disturbances (e.g., storm surges [see Factor E]) can cause vegetation to change sooner than projected based on sea level alone.

The Science and Technology Committee of the Miami-Dade County Climate Change Task Force (MDCCCTF) (2008, p. 1) recognized that significant sea level rise is a very real threat to the near future for Miami-Dade County. In a January 2008 statement, the MDCCCTF (2008, p. 2-3) warned that sea-level is expected to rise at least 3-5 feet (0.9-1.5 m) within this

century. With a 3-4 foot (0.9-1.2 m) rise in sea level (above baseline) in Miami-Dade County: "Spring high tides would be at about + 6 to 7 feet; freshwater resources would be gone; the Everglades would be inundated on the west side of Miami-Dade County; the barrier islands would be largely inundated; storm surges would be devastating; landfill sites would be exposed to erosion contaminating marine and coastal environments. Freshwater and coastal mangrove wetlands will not keep up with or offset sea level rises of two feet per century or greater. With a five foot rise (spring tides at nearly +8 feet), Miami-Dade County will be extremely diminished." MDCCCTF 2008, p. 2-3)

In general, sea level rise is considered a long-term threat (NatureServe 2009, p. 1). In summary, all known occurrences are at some risk to habitat loss and modification because all occurrences are in low-lying areas and will be affected by rising sea level. We find the magnitude of the threat due to habitat loss from development is low and non-imminent, as this was mostly a historic loss. We find that the threat of sea level rise is currently moderate and imminent. However, even though the overall threat level of habitat loss from sea-level rise is currently moderate, it is expected to become severe in the future. All extant occurrences are located on conservation lands. Existing suitable habitat on conservation lands is threatened by natural and environmental factors.

- B. Overutilization for commercial, recreational, scientific, or educational purposes. Collecting by cactus hobbyists may have eliminated the species from Big Pine Key and Key Largo in the late 1970s. Poaching is still a major threat to this species (Gann *et al.* 2002, p. 481). Although the remaining wild populations on Little Torch Key and Swan Key and the outplanted populations in Key Largo and the lower Keys are largely protected due to their location on conservation lands, plants are vulnerable to illegal collection and vandalism. Vandalism has occurred at Little Torch Key, one cactus (cactus #5) was impacted by vandalism twice (Slapcinsky *et al.* 2006, p. 3). In 1990, branches were cut off and left on site and in 2003 vegetative recruits and pads were damaged by people moving the cage frames; in 2005 this cactus died (Slapcinsky *et al.* 2006, p. 3). Another cactus (cactus #6) was damaged the same way in 2003 (Slapcinsky *et al.* 2006, p. 3). In addition, all of the stakes at the bases of one plant were removed in 2003 (Slapcinsky *et al.* 2006, p. 4). We find that these threats are intermittent, but recurring, and due to the limited number of plants, the magnitude of these threats is considered to be moderate and imminent. Therefore we find that the overall threat level posed by poaching and vandalism is moderate.
- C. Disease or predation. The Florida semaphore cactus is threatened by an exotic moth native to South America whose larvae burrow into the cactus pad and feed on the tissue. The moth, *C. cactorum*, was introduced with success into Australia from Argentina in 1925 to control several North and South American species of *Consolea*, enabling large expanses of infested lands to be reclaimed for agricultural purposes (Habeck and Bennett 1990, p. 3). The moth was introduced into several Caribbean islands from 1957 to 1970 and subsequently spread throughout the Caribbean and Florida Keys to as far north as Key Biscayne (Habeck and Bennett 1990, p. 3). The first moth was encountered in the Keys in 1989. *Cactoblastis* rapidly infested many Florida cacti, with up to 60 percent of the common *Opuntia stricta* plants attacked and many individuals completely destroyed (Stiling *et al.* 2000, p. 2). This moth is now present on most Caribbean islands as a consequence of mostly deliberate or

accidental introductions by humans or through natural spread (Zimmermann *et al.* 2005, p. 2).

An infestation of *C. cactorum* in April 1994 killed the main stem of an adult Florida semaphore cactus (cactus #2) on Little Torch Key (Slapcinsky *et al.* 2006, p. 2). All but five cacti were protected from moth infestation by screen enclosures until September 1998 when the enclosures were removed prior to Hurricane Georges; there are no plans to reconstruct them (Slapcinsky *et al.* 2006, p. 2). In 1996, Stiling *et al.* (2000, p. 3) reported that *Cactoblastis* destroyed one mature cactus, but did not kill any outplanted individuals. In a second outplanting in 1998, more than 50 percent of the cacti were killed by *Cactoblastis* within 3 years (Stiling 2007, p. 2). *C. cactorum* was very active in 1999 (Slapcinsky *et al.* 2006, p. 3). Three pads of cactus #3 were lost and cactus #12 was infested in 2000 (Slapcinsky *et al.* 2006, p. 3). In a third outplanting in 2000, no cacti were attacked by *Cactoblastis* (Stiling 2007, p. 2). Biweekly monitoring of the cacti for *C. cactorum* eggs and larvae was instituted on Little Torch Key in 2000 (Slapcinsky *et al.* 2006, p. 1). TNC checks for moths every month or every other month and there have not been signs of moths in more than 5 years (Slapcinsky *et al.* 2006, p. 2; A. Higgins, pers. comm. 2007). However, TNC still considers the cactus to be vulnerable to sudden decline from *C. cactorum* infestation (Slapcinsky *et al.* 2006, p. 4).

Grahl and Bradley (2005, p. 7) did not detect the moth on Swan Key, and surveys of population in 2008 and 2009 yielded no evidence of cactus moth damage (V. McDonough, pers. comm. 2008; pers. comm. 2010a); however, given its ability to spread, researchers believe it may colonize the island in the future. Continued monitoring is needed to detect an invasion. Grahl and Bradley (2005, p. 7) recommended that managers at BNP develop contingency plans before *C. cactorum* becomes established there so that managers can respond quickly to this threat. Predation from *C. cactorum* is considered to be a major threat to this species (Stiling *et al.* 2000, p. 2, 6, Gann *et al.* 2002, p. 481; Wright and Maschinski 2004, p. 4; Grahl and Bradley 2005, p. 2, 7; Slapcinsky *et al.* 2006, p. 2-4), and no satisfactory method of control is known at this time. The widespread use of pesticides to control *C. cactorum* is not recommended because of the occurrence of imperiled butterflies; releases of egg parasites such as *Trichogramma* could also have an adverse impact on other desirable Lepidoptera (Habeck and Bennett 1990, p. 3; Habeck *et al.* 2009, p. 2). Classic biological control should be considered, but more study is needed before such controls are used (Habeck and Bennett 1990, p. 3; Habeck *et al.* 2009, p. 2).

Many of the individuals in the population on Little Torch Key and individuals outplanted in the lower Keys are suffering from root rot (Stiling 2007, p. 2). The pathogen is unknown. At present, root rot does not appear to be affecting the population at BNP. In 1997, cacti #7 and #9 at Little Torch Key lost their main stems to rot and unknown causes, respectively (Slapcinsky *et al.* 2006, p. 2). Cactus #12 also started withering and dropping pads in 2002; samples were submitted to Florida State Department of Pathology, but no causes determined (Slapcinsky *et al.* 2006, p. 3). Foliage from vegetative recruits of cactus #3 was tested and found positive for a fungus, *Phomopsis* sp. (Slapcinsky *et al.* 2006, p. 3).

Stiling *et al.* (2000, p. 1) found both natural and outplanted populations declined by 30

percent during their monitoring periods. In both natural and outplanted populations, they found most individuals died from what appeared to be stem browning, probably by a plant pathogen (Stiling *et al.* 2000, p. 1-6). The next largest cause of mortality in the outplanting was from trampling, most likely from Key deer (Stiling *et al.* 2000, p. 5). More recently, Stiling (2007, p. 2) found 75 percent of outplanted individuals were killed by root rot in 6 years at one site. Survival rate of outplanted cacti in general has been poor because of root rot (Stiling 2007, p. 2). In addition, of 156 naturally occurring vegetative recruits marked in 1999 only 67 (about 43 percent) remained alive by 2007; most have succumbed to root rot (Penniman and Slapcinsky 2007, p. 42).

In summary, we find the magnitude of the threats presented by disease and predation to be high and imminent, being that they are both current and future threats to the species. Overall threat level is severe from the cactus moth predation and high for root rot disease.

- D. The inadequacy of existing regulatory mechanisms. The Florida Department of Agriculture and Consumer Services (FDACS) designated the Florida semaphore cactus under the name of *Opuntia corallicola* as endangered under the Chapter 5B-40, Florida Administrative Code. This listing regulates commercial trade, but provides little or no habitat protection beyond the State's Development of Regional Impact process. This process serves to disclose impacts from projects, but provides no regulatory protection for State listed plants on private or federal lands. Without local or county ordinances preventing the destruction of the plant, conservation of the species does not occur. At present, no physical protection is provided for the plant and access is not restricted; however, the location of the plant is not made known to the general public. At the Dagny Johnson Key Largo Hammock Botanical State Park in North Key Largo, no additional protection above and beyond what is given to other plant species occurring on State property is given to the Florida semaphore cactus. We find the magnitude of this threat to be moderate and imminent, overall the threat level is moderate.
- E. Other natural or manmade factors affecting its continued existence. Only two wild populations remain; only one appears large enough to be viable. While the population at Swan Key appears to be stable (V. McDonough, pers. comm. 2010a), the population at Little Torch is small and declining. Outplanted cacti on Big Pine Key, Cudgoe Key, Ramrod Key, and No Name Key have died; only 7 of 180 individuals remain at Saddlebunch Key (P. Stiling, pers. comm. 2009). Only eight of 142 outplanted individuals remained alive at Dagny Johnson Key Largo Hammock State Botanical Park in November 2008 from efforts in 1996, 2003, and 2004 (J. Duequesnel, pers. comm. 2009). Overall, outplanting attempts have either failed or, at best, been only marginally successful.

Hurricanes and other natural disasters can be devastating to small populations. High winds associated with Hurricane Katrina (Category 1) and Hurricane Wilma (Category 2) in 2005 caused a high number of vegetative pads to fall off at Swan Key (Grahl and Bradley 2005, p. 6). Little Torch Key, as well as the rest of the lower keys, was impacted greatly by Hurricane Georges in 1998 (Slapcinsky *et al.* 2006, p. 2). Winds and water associated with the Hurricane Georges were responsible for the death of two adult cacti (#3 and #11) and many vegetative recruits at Little Torch Key; damage to several other adults and vegetative recruits also occurred (Slapcinsky *et al.* 2006, p. 2-3). Cactus #1 lost several small pads and

one vegetative recruit was buried in storm debris or swept away (Slapcinsky *et al.* 2006, p. 2). Cactus #4 lost almost all of its branches, leaving only one branch, one pad, and one vegetative recruit (Slapcinsky *et al.* 2006, p. 3). Cactus #5 lost all parts, except its main stem, which survived the storm (Slapcinsky *et al.* 2006, p. 3). Cactus #6 lost nine pads, cactus #10 was bent by the wind, cacti #11 and #3 were snapped in half by winds, and cactus #13 was lost (Slapcinsky *et al.* 2006, p. 3). In addition, many vegetative recruits were lost in the storm, however, it is possible that debris may have simply covered them (Slapcinsky *et al.* 2006, p. 3). Some cacti succumbed to unknown causes following the storm (Slapcinsky *et al.* 2006, p. 3). Hurricane Wilma flooded the entire hammock on Little Torch Key with salt water (A. Higgins, pers. comm. 2007). There was not a marked decline from this event, but an overall declining trend is occurring (A. Higgins, pers. comm. 2007). The State has reported that saltwater intrusion and overwash associated with tropical storms and hurricanes continues to impact the introduced population at Dagny Johnson Key Largo Hammock Botanical State Park (J. Duquesnel, pers. comm. 2008, 2009).

Recent genetic studies have shown no variation within populations and very limited variation between populations (Francisco-Ortega *et al.* 2004, p. 3, 9; Cariaga *et al.* 2004, p. 159; C. Lewis, pers. comm. 2006). In their work to determine the genetic structure between populations, Cariaga *et al.* (2004, p. 159) found that populations are virtually identical, indicating that vegetative propagation has been the main life history of this species. Genetic analyses indicated that the plants at Swan Key are essentially genetically identical to previously known individuals (Cariaga *et al.* 2004, p. 159). Findings support the conclusion that the Swan Key (upper Keys) and Little Torch Key populations and Big Pine Key (lower Keys) individual are clonally derived. There is some disagreement as to whether the Little Torch Key and Big Pine Key populations are genetically distinct from each other (Cariaga *et al.* 2005, p. 229-231, Lewis 2007, p. 6). Studies examining the reproductive biology of the species indicate that all extant wild and cultivated plants are male (Negrón-Ortiz 1998, p. 208-212; Negrón-Ortiz and Strittmatter 2004, p. 22; Negrón-Ortiz 2007a, p. 6; Lewis 2007, p. 6). Populations consisting of only males will lack the capacity for adaptation and will be more prone to extinction. Lack of variation and limited sexual reproduction makes the remaining populations more susceptible to natural or manmade factors.

The remaining populations appear to reproduce solely by vegetative progeny (NatureServe 2009, p. 2). Dispersal beyond these sites is not expected since the majority of progeny fall within 100 meters (328 feet) of the parent plant (NatureServe 2009, 2). At this time, human-assisted propagation and reintroduction may be the best way to maintain or expand the populations.

The NPS indicates that competition with invasive exotic plants is a threat to the population at Swan Key (V. McDonough, pers. comm. 2010a). In 2008, BNP successfully competed for NPS funds to treat exotic plants that pose a threat to the Florida semaphore cactus (V. McDonough, pers. comm. 2010a). In November and December 2009, the funding was used to contract a company to treat and remove invasive exotic plants on Swan Key, as well as surrounding Keys (V. McDonough, pers. comm. 2010a). The species primarily targeted was seaside mahoe (*Thespesia populnea*), however other exotics were also removed including, Brazilian pepper (*Schinus terebinthifolius*), sapodilla (*Manilkara zapota*), latherleaf

(*Coulbrina asiatica*), and sea hibiscus (*Hibiscus tiliaceus*) (V. McDonough, pers. comm. 2010b). Methods include manual removal, cut stump, and/or basal treatment of herbicides such as Garlon (V. McDonough, pers. comm. 2010b). At this time, we cannot fully assess the degree to which invasive exotic plants threaten the Swan Key population; presently, this threat appears moderate in magnitude (V. McDonough, pers. comm. 2010b). Since actions are being taken by NPS to address invasive exotic plants and the overall population at Swan Key appears stable, this threat is considered to be non-imminent.

In summary, Florida semaphore cactus is vulnerable to a wide array of natural and human factors, including: hurricanes and extreme weather events, storm surges, competition from exotic species, lack of variation and limited sexual reproduction, low genetic diversity, small and isolated occurrences, and restricted range. We find that all of these threats are high magnitude and imminent. The overall level of threat is high from weather events, and severe from reproductive and genetic factors.

## CONSERVATION MEASURES PLANNED OR IMPLEMENTED

The management objective for TNC is to maintain or increase the population on Little Torch Key (Slapcinsky *et al.* 2006, p. 1). Research on the Swan Key population is being or has been conducted by: Vivian Negrón-Ortiz previously of Miami University (now with the Service), researchers from FTBG and IRC, and staff from BNP.

FDACS has participated in research and studies on restoration since 1993 using Endangered Species Act Section 6 funding. In 2005, FDACS provided funds to the University of South Florida to determine vegetative recruit success at Little Torch Key.

Stiling and other researchers are testing the habitat requirements and vulnerability to the cactus moth of reintroduced propagules and examining whether any genetic differentiation in response to the habitat is evident (Penniman and Slapcinsky 2007, p. 57). Monitoring of this outplanting will help estimate population viability (Penniman and Slapcinsky 2007, p. 58). In a separate study, Stiling is testing the effect of fertilization of the cactus on outplanting success (Penniman and Slapcinsky 2007, p. 58). The objective of this study is to test the effect of more active management on success of outplantings; half the cacti were fertilized and half were not treated in each area (Penniman and Slapcinsky 2007, p. 58).

FTBG maintains this species in its Center for Plant Conservation living collection of endangered plants. It has propagated plants collected from the Little Torch Key population in an effort to transplant them at Big Pine Key and Key Largo. Propagules have been provided to researchers from the University of South Florida, FDEP, U.S. Department of Agriculture, and TNC for research, augmentations, and introductions of new populations in historically appropriate and protected habitats. Organizations involved in the reintroductions include: FTBG, Florida Park Service, TNC, and University of South Florida (Gann *et al.* 2002, p. 481). Results of these activities have yet to be determined. The genotype from BNP has also been acquired by FTBG (Francisco-Ortega 2004, p. 10).

FTBG created two site maps, conducted biological and ecological studies, and completed a

Conservation Action Plan in 2001 (Fellows *et al.* 2001, p. 3, 8). In 2001, experiments were designed to test the salinity tolerance of the Florida semaphore cactus to determine if increased salinity may be contributing to the apparent decreased fitness (yellowing, disease, failure to reproduce sexually) at Little Torch Key (Fellows *et al.* 2001, Appendix E4, p. 1). It was theorized that in recent decades, mosquito ditching, sea level rise, and excavation of boat canals for the Jolly Rogers Estates have increased salinity at Little Torch Key (Fellows *et al.* 2001, Appendix E4, p. 1). Experiments were broken into salinity study (core), seasonal salinity study, and hurricane study (Fellows *et al.* 2001, Appendix E4, p. 1-4). Preliminary results showed that cacti are sensitive to much lower salinity levels than 17 parts per thousand (Fellows *et al.* 2001, Appendix E4, p. 2). However, additional follow-up studies are needed both in the laboratory and under field conditions for a more complete understanding of the ramifications of increased salinity on plant survival.

FTBG's Conservation Action Plans are intended to present all available information on the biology, ecology, protection, threats, and previous research on each species as well as possible management options (Fellows *et al.* 2001, p. 37). A Conservation Action Plan was completed in 2001 (Possley *et al.* 2001, p. 1-9) and updated in 2003 (Possley *et al.* 2003, p. 195-203) and 2004 (Possley *et al.* 2004, p. 161-167). Management options identified included: outplanting, habitat modification, hand pollination, pest removal, and genetic studies (Possley *et al.* 2001, p. 1-9; 2003, p. 195-203, 2004, p. 161-167).

FTBG helped map the newly discovered population at Swan Key with IRC in 2002 and secured a contract with BNP to examine the genetic diversity of this population (Maschinski *et al.* 2002, p. 25). In addition, FTBG conducted monitoring BNP and Torchwood Hammock Preserve (Maschinski *et al.* 2002, Appendix B1, p. 10; p. 5). In 2003 and 2004, FTBG continued monitoring BNP with IRC, collecting data on survival, growth, and phenology (Maschinski *et al.* 2003, p. 5; Maschinski *et al.* 2004, p. 5).

In 2003, FTBG collected material from the Swan Key population and determined most effective protocol for DNA extraction (Maschinski *et al.* 2003, p. 5; Maschinski *et al.* 2004, p. 5). The study will provide direct recommendations for conservation action, easily interpreted summaries of genetic information, precise maps of the plants and their genetic variation, and simple diagrams of the genetic structure of both wild populations (Wright and Francisco-Ortega 2003, p. 193).

The Service provided funding to a variety of entities for conservation of the cactus in 2005. The Service funded a study by researchers at Miami University to examine the reproductive biology of Florida semaphore cactus from BNP; this study has been completed (Negrón-Ortiz 2007a, p. 1-7). We also funded a study in 2005 by researchers at FTBG to examine new DNA fingerprinting techniques for managing wild populations of the cactus; this study has been completed (Lewis 2007, p. 1-9). In addition, the Service funded a study by researchers at IRC for monitoring of the Florida semaphore cactus on Swan Key. This study was completed in December 2005 (Grahl and Bradley 2005, p. 1-21).

U.S. Department of Agriculture researchers are examining effectiveness of biological controls of *C. cactorum* on many *Opuntia* species, including the Florida semaphore cactus (Wright and

Maschinski 2004, p. 6).

The NPS is monitoring the population at Swan Key (see Description of Monitoring below) and taking action to combat the threat of invasive exotic plants at the Swan Key population (V. McDonough, pers. comm. 2010a, 2010b).

## SUMMARY OF THREATS

Only two natural, wild populations are extant, one of which is small and in decline, the other of which is relatively stable. Although habitat loss has caused the extirpation of this species at some locations, it is not a current threat since all populations are on conservation lands; however, human population growth in the Keys makes this a threat in the future. Sea level rise is considered a serious threat to the species and its habitat. Climatic changes and sea level rise are long-term threats that will continue; these factors are expected to continue to impact and ultimately substantially reduce the extent of available habitat, especially in the Keys. Remaining natural populations and outplanted individuals are threatened by an exotic moth whose larvae burrow into the cactus pad and feed on the tissue; the threat from predation is considered urgent and significant. Plants are also susceptible to unknown pathogens and frequently exhibit root rot. This species is inherently vulnerable to stochastic losses, especially at its smaller populations. A lack of variation and limited sexual reproduction makes the remaining small populations more susceptible to natural or manmade factors. Collecting and poaching are considered significant threats. Hurricanes Georges, Katrina, and Wilma impacted the species, and the threat from hurricanes is expected to continue. Competition from invasive exotic plants is a moderate threat to the Swan Key population, but it is being addressed by the NPS. We find that this species is warranted for listing throughout all its range, and, therefore, find that it is unnecessary to analyze whether it is threatened or endangered in a significant portion of its range.

## RECOMMENDED CONSERVATION MEASURES

- Continue monitoring on Little Torch Key, as outlined by TNC (Slapcinsky *et al.* 2006, p. 1-12). Close monitoring of Torchwood Hammock Preserve is needed so that *Cactoblastis* moth larvae can be removed; such intervention is likely needed if the cactus is to survive for the next 10 years (Possley *et al.* 2004, p. 166).
- Continue monitoring Swan Key to detect the invasion of the exotic moth (Grahl and Bradley 2005, p. 7). Develop a contingency plan for BNP before the moth becomes established so that managers can respond quickly to this threat (Grahl and Bradley 2005, p. 7).
- Establish and maintain an *ex situ* collection of the main adults (either the *ex situ* collection already established at FTBG or a new one) (Negrón-Ortiz 2006b, p. 6). *Ex situ* collections will play an important role in the conservation of the species; emerging genetic data will be critical for building and maintaining useful *ex situ* collections (C. Lewis, pers. comm. 2006).
- Propagate the species vegetatively for *in situ* and *ex situ* conservation (Francisco-Ortega *et al.* 2004, p. 9-10).
- Examine the need to determine the closest *Consolea* species related to the Florida semaphore cactus and if needed explore the need to initiate a hybridization and breeding program to develop female plants (Negrón-Ortiz 2006b, p. 6).

- Consider treating outplanted cacti with a fungicide to determine if this treatment will increase vegetative recruit survival and outplanting success (Stiling 2007, p. 3).
- Use the knowledge obtained from the research on ‘heterochrony and its role in sex determination of *Consolea* (Cactaceae) staminate flowers’ to determine whether it is feasible to hand-pollinate flower buds, when ovules are viable, and obtain seeds in this way (Negrón-Ortiz 2006b, p. 6; Strittmatter *et al.* 2008, p. 305-326).
- Conduct research to determine the necessary habitat requirements and coordinate more outplantings in suitable habitat (Possley *et al.* 2004, p. 166). Outplanting should be used to buffer the species from local extinction risk, given there are only two wild populations and few successful outplantings (Possley *et al.* 2004, p. 166).
- Conduct research on salinity tolerance both in the laboratory and under field conditions.
- Explore ways to control *C. cactorum*.

#### LISTING PRIORITY

THREAT			
Magnitude	Immediacy	Taxonomy	Priority
<b>High</b>	<b>Imminent</b>	Monotypic genus	1
		<b>Species</b>	<b>2*</b>
	Non-imminent	Subspecies/population	3
		Monotypic genus	4
		Species	5
Moderate to Low	Imminent	Subspecies/population	6
		Monotypic genus	7
		Species	8
	Non-imminent	Subspecies/population	9
		Monotypic genus	10
		Species	11
		Subspecies/population	12

Rationale for listing priority number:

**Magnitude:** The extant populations, consisting of two wild populations and a few outplanted populations, are threatened by climatic changes and sea level rise. These are serious and long-term threats that will reduce the extent of habitat. All occurrences are threatened by an exotic moth. Plants are also susceptible to unknown pathogens and frequently exhibit root rot. Overall threat level is severe from the cactus moth predation and high for root rot disease. This species is inherently vulnerable to stochastic losses, especially at its smaller populations. A lack of variation and limited sexual reproduction makes the remaining small population even more susceptible to natural or manmade factors. Collecting and poaching are considered major threats. Hurricanes have impacted this species and the threat of additional hurricanes and storms is high. The extent of invasive exotic plants at the Swan Key population is not fully known, but thought to be moderate; NPS is taking action to reduce this threat. Overall, we find the magnitude of these threats is high.

*Imminence:* All extant populations are located in low-lying areas. Sea level rise is currently occurring and appears to have already impacted one population. All remaining populations are under threat of predation from the exotic moth. The moth has already been documented at the Little Torch Key population and has infected two plants at this site; one died as a result (Stiling and Moon 2001, p. 508-509; Slapcinsky *et al.* 2006, p. 3). In one outplanting in 1998, over 50 percent of the cacti were killed by *Cactoblastis* within 3 years (Stiling 2007, p. 2). The moth has not been detected on the population in BNP (V. McDonough, pers. comm. 2010a), but the likelihood of it reaching this population is high based on the rapid spread of the species in the Caribbean and Florida (Bradley and Koop 2003, p. 6; Grahl and Bradley 2005, p. 7). Root rot is currently occurring and has impacted outplanted populations. A lack of variation and limited sexual reproduction makes the remaining small populations even more susceptible to natural or manmade factors. Genetic diversity needs to be maintained. Since actions are being taken by NPS to address the threat of invasive exotic species at BNP, we consider the threat of invasive exotic plants to be non-imminent. We find the overall immediacy of threat to be imminent.

Rationale for Change in Listing Priority Number (insert if appropriate):

Yes Have you promptly reviewed all of the information received regarding the species for the purpose of determining whether emergency listing is needed?

Is Emergency Listing Warranted? No. The larger population at BNP appears to be relatively stable. The small Little Torch Key population is on property owned and managed by TNC. All populations need to be monitored closely to detect for presence of the moth. There is interest in monitoring these populations on the part of NPS, TNC, University of South Florida, and other entities. Research habitat requirements should be conducted; additional outplantings in suitable habitat should be pursued.

#### DESCRIPTION OF MONITORING

TNC has monitored the cactus on Little Torch Key since 1991 (Slapcinsky *et al.* 2006, p. 1; Penniman and Slapcinsky 2007, p. 41). Objectives of their monitoring program are to maintain all known adult cacti in either stable or increasing numbers through a biannual census and to measure growth as an early indicator of individual decline (Slapcinsky *et al.* 2006, p. 1). Parameters measured per cactus include: maximum height, number of branches, number of pads, number of bud vases, flowers and dead flowers, number of fruits, and number of vegetative recruits (Slapcinsky *et al.* 2006, p. 2). According to TNC, monitoring objectives have not been met because they have not been successful in maintaining all known adult cacti (Slapcinsky *et al.* 2006, p. 4).

Stiling is conducting a project to quantify vegetative recruit success on Little Torch Key (Penniman and Slapcinsky 2007, p. 42). Objectives are to initiate long-term monitoring of growth and survival of naturally occurring vegetative recruits and measure the physical properties of the natural environment, including light, soil pH, soil salinity and soil nutrient levels (Penniman and Slapcinsky 2007, p. 42). Monitoring of individuals outplanted to Little Torch Key is continuing.

The Swan Key population has been monitored since 2002 (Grahl and Bradley 2005, p. 2). Monitoring is conducted to determine the basic aspects of the species' life history, to detect the presence of the introduced moth, and to look for poaching (Grahl and Bradley 2005, p. 2). This population was regularly monitored in 2005 by IRC (Grahl and Bradley 2005, p. 2, 4) and in 2002-2003 (Bradley and Koop 2003, p. 1-17). The NPS resumed monitoring of the Swan Key population, conducting two surveys per year starting in May 2008 (V. McDonough, pers. comm. 2010a). All individuals are tagged and measurements are taken on trunk height, number of pads, number of buds and open flowers, as well as presence of the cactoblastis moth (V. McDonough, pers. comm. 2010a). The approach used by the NPS is consistent with previous surveys conducted by Keith Bradley and others at IRC (V. McDonough, pers. comm. 2010a).

## COORDINATION WITH STATES

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment: The Service requested new information (observations, data, reports) regarding the status of this plant or any new information regarding threats to this species from: FDACS, NPS, Service (National Wildlife Refuges), FDEP, Miami-Dade County, Florida Fish and Wildlife Conservation Commission, FNAI, IRC, Historic Bok Sanctuary, TNC, FTBG, Archbold Biological Station, NatureServe, University of Central Florida, Florida International University, University of Florida, Princeton, members of the Rare Plant Task Force, botanists, and others. In total, the previous assessment was sent to approximately 200 individuals.

The State of Florida does not include plants in the State Wildlife Action Plan.

Indicate which State(s) did not provide any information or comments: None.

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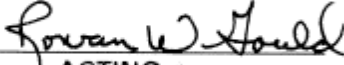
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APPROVAL/CONCURRENCE: Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve:  June 15, 2010  
for Regional Director, Fish and Wildlife Service Date

Concur:  October 22, 2010  
ACTING :  
Director, Fish and Wildlife Service Date:

Do not concur: \_\_\_\_\_  
Director, Fish and Wildlife Service Date

Director's Remarks:

Date of annual review: May 4, 2010  
Conducted by: Paula Halupa, South Florida Ecological Services Office